Integrated Forest Protection Guide

Western Spruce Budworm in the Southwest

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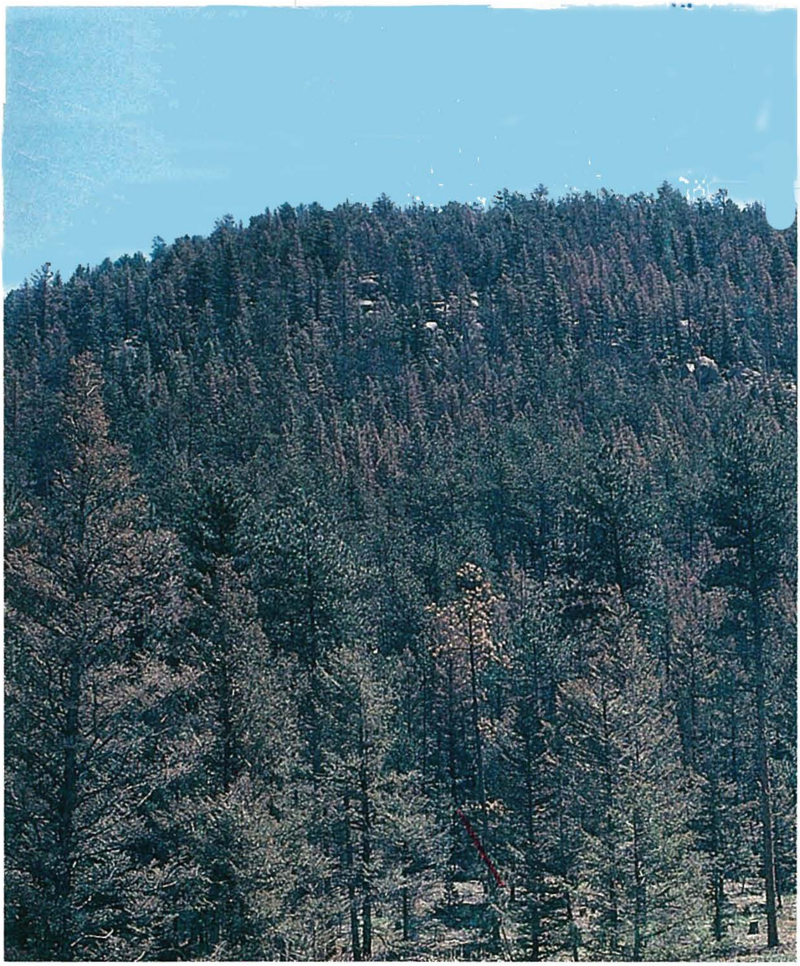
by James P. Linnane



Integrated Forest Protection Guide

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Contents

Introduction

The western spruce budworm, Choristoneura occidentalis, is the principal insect defoliator within the mixed conifer forest type in Arizona and New Mexico. This native insect is widely distributed throughout the western United States and Canada and can be found on all National Forests within the Southwestern Region where substantial mixed conifer type exists. The western spruce budworm (WSB) defoliates the new growth of its' hosts. In the Southwest, these are principally Douglas-fir, Pseudostsuga menziesii, and white fir, Abies concolor var. concolor. Hosts affected to a lesser degree include blue spruce, Picea pungens, corkbark fir, A. lasiocarpa var. arizonica, and Engelmann spruce, P. engelmannii. Outbreaks of this insect result in tree growth loss, top-kill, destruction of seeds and cones, tree mortality, and stand regeneration failures, as well as adversely affecting recreation and aesthetic values. Tree damages and losses are directly related to the intensity and duration of outbreaks.

The western spruce budworm can adversely influence planned resource objectives and outputs, both short- and long-term, from National Forest System lands and lands of other ownerships as well as the public's perception of a pristine forest environment. This guide's objective is to bring together relevant information providing a model for management under integrated forest protection or integrated pest management principles [1]. The information used to develop this management guide has been gained through research, pilot projects, biological evaluation surveys, and the observations and experiences of forest and pest management specialists. This guide incorporates the best current knowledge; however, as new information becomes available, modifications to this guide will be necessary.

Western Spruce Budworm Biology

The adult WSB is a small, bell-shaped moth with a wingspan of 22 to 28 mm (7/8 to 1-1/8 inches). The moth's forewings are mottled gray to orange brown in color. Adults emerge, mate, and disperse from early July to early August in the Southwest. During this period, adult females deposit their compliment of eggs on the undersides of host-tree needles. These eggs are light green, oval shaped, 1.2 mm (3/64 inch) long, and found in overlapping shingle-like masses. The eggs hatch generally within 10 days after deposition.

There are six larval or caterpillar stages. Newly hatched larvae are present in August. They do not feed, but shortly disperse and seek overwintering sites under scales, lichens, and other sheltered locations on tree branches and limbs. At these sites, larvae construct "silken tents" or hibernacula and remain inactive throughout the winter. In the spring, these caterpillars leave their overwintering sites and initially mine buds and old needles. As new shoots flush and expand, larvae move to these sites, often webbing shoots together, feeding on the new needles. Immature larvae are small, yellow-green in color with brown to black heads. Mature larvae are approximately 25 to 32 mm (1 to 1-1/4 inches) in length, have brownish colored heads and olive colored bodies with conspicuous whitish dots on the dorsal side (Figure 1). Approximately 30 to 40 days are necessary for larvae to mature after leaving overwintering sites in the spring. Larvae can be found from May through late June in the Southwest.

Mature larvae pupate in silken webs at the last feeding sites or elsewhere on the foliage. Pupae are 13 to 16 mm (1/2 to 5/8 inch) in length and brown to yellow brown in color. During the pupation period, larvae transform to adult moths. The pupal stage is approximately 10 days in length.

Western spruce budworm larvae, particularly the mature stages, defoliate the new growth of host trees almost exclusively (Figure 2). This feeding damage results in tree crowns assuming a reddish tinge; the red tinge being the defoliated twigs and dying needles caught in feeding webs. Several years of intensive feeding results in trees being nearly completely defoliated.

Western spruce budworm population densities are regulated by several natural factors during the insect's life stages. There are more than 40 species of insect parasites which attack the egg, larval, and pupal stages. Numerous invertebrate and vertebrate predators including small mammals and birds prey on all WSB life stages. Adverse weather conditions, particularly a late spring frost, can

adversely impact budworm populations. Starvation can be an important mortality factor in chronic, high density WSB populations. These natural regulating factors, particularly predation, are important in maintaining WSB populations at endemic levels. However, these factors cannot always prevent an epidemic population surge, when forest stand and climatic conditions become favorable for WSB.

Western spruce budworm outbreaks are periodic in occurrence and range in duration from a few years to over a decade. Outbreaks range in size from a few thousand acres to massive areas involving nearly the entire host type. In the Southwest, the first documented outbreak occurred between 1922 and 1935 in northern New Mexico. However, dendrochonological evidence suggests the occurrence of outbreaks as far back as the late 1750's [2]. Since the early 1900's, outbreaks have occurred during every decade. The current outbreak in northern New Mexico began in the mid-1970's and appears to be longer in duration and more intense than previously recorded outbreaks [2].

Figure 1. A mature WSB larva.

Figure 2. Heavily defoliated new growth of white fir.

Figure 3. Stand conditions highly susceptible to WSB.

Forest Susceptibility

Chronic, lengthy WSB epidemics are a symptom of increasing forest susceptibility to budworm and a resulting decline in forest health. In this respect, this insect is an indicator of reduced forest vigor and a general trend towards a greater area dominated by climax forest plant associations on WSB susceptible habitat types. An ecological role of WSB may be the maintenance of climax plant associations by creating small overstory openings allowing successful reproduction and replacement of shade-tolerant tree species after periodic epidemics.

Forest stands most susceptible to WSB are multi-storied with white fir and Douglas-fir predominating the overstory, densely stocked to overstocked, and mature with low vigor (Figure 3). The understory is composed almost entirely of shade-tolerant species. The most susceptible stands are on mesic white fir habitat types. When stands with these conditions comprise large contiguous areas, forest susceptibility is high. Similar stands of Engelmann spruce, blue spruce, and corkbark fir are also susceptible, but to a lesser degree than white fir and Douglas-fir.

The western spruce budworm has become a persistent pest during the last few decades. Many resource managers and entomologists believe fire management and past logging practices are primary factors in this persistence [3]. The influence of these factors enhances the creation of highly susceptible stands. As these stands reach maturity, they become increasingly susceptible and vulnerable to damage from budworm outbreaks. Thus, budworm outbreaks become persistent and severe and stand damages increase.

Prior to 1900, fire played an important role in mixed-conifer forest succession in the Southwest. Fire histories (at elevations less than 9,000 feet) consisted of "frequent, small, low-intensity fires, and fires that burned over larger areas at a mean fire interval of roughly 22 years [4]." Fire favored the regeneration of ponderosa pine, increased stand-age diversity by increasing younger age class representation (fire initiates natural regeneration), and reduced stand basal area [4]. At elevations above 9,000 feet, fire tended to be less frequent, but more severe. At higher elevations, conifer stands were often replaced by aspen as a result of fire. Fire, at least prior to 1900, had a tendency to reduce stand susceptibility to WSB [5].

Fire management and suppression, by reducing the frequency and area of large fires, has tended to maintain mixed-conifer stands in a budworm susceptible state and permit nonhost and less susceptible stands to advance to a more susceptible state. In general, fire management has

accelerated climax forest succession and contributed to the more frequent and intensive budworm outbreaks observed during the last few decades.

Past logging practices are another factor affecting forest succession and susceptibility to western spruce budworm. During the early decades of this century and possibly the late 18th century, a version of the selection method of silviculture was extensively applied [6]. The biggest and best trees were logged. Cutting rotations were long, and little emphasis was placed on stand regeneration, composition, and stocking. Intermediate cuts were seldom considered.

In mixed-conifer stands, the most economically desirable species are ponderosa pine and Douglas-fir, with ponderosa pine, by far, the most valuable. In many stands ponderosa pine represented the principal seral species and as logging removed pine without adequate regeneration considerations, shade-tolerant, climax budworm host species replaced the pine. Combined with fire management, these past logging practices have contributed to increased forest susceptibility to budworm.

Stand Damages

Defoliation results in a variety of tree damages including growth loss, top-kill, tree mortality, and reduced aesthetic and visual values. Trees can withstand 1 or 2 years of defoliation with little impact. However, several consecutive years of defoliation results in cumulative tree and stand damages effecting resource values and outputs.

Seed and Cones

The staminate flowers and developing cones are an excellent and preferred food source for budworm larvae. Thus, intensive larval feeding adversely effects cone crops, if not totally destroying them. In severely infested stands, cone production may be sparse for several years after budworm feeding ceases [7]. This decline in seed production results in inadequate natural regeneration.

Understory

Western spruce budworm often severely damages seedling-, sapling-, and pole-size class trees by repeated defoliation (Figure 4). Long-term damage assessments on the Carson National Forest indicate measurable top-kill and mortality in pole-, sapling-, and seedling-size classes appears after 3 to 4 years of defoliation [8]. Top-kill can be severe in pole-size stands, with as much as 30% of the host trees displaying top-kill after 5 years of defoliation [9]. The vulnerability of these younger size classes increases when larvae, dispersing from infested overstory trees, establish themselves on understory foliage. Thus, severe and persistent defoliation will result in significant top-kill and mortality.

The principal impact of understory damage is in managed stands where this understory is the advanced regeneration under shelterwood or seed-tree silvicultural systems. In these cases, the WSB often causes failures in adequate natural regeneration and inadequate stocking levels.

Christmas tree production areas are also severely damaged by defoliation. Only single year's defoliation will significantly reduce the Christmas tree's value. Several consecutive years of defoliation will completely destroy the crop.

Overstory

Western spruce budworm damage to mature overstory includes radial growth loss, top-kill, and tree mortality. Radial growth loss, in most infestation situations, has the greatest impact. Generally, annual radial increment can be reduced by more than 50% as a result of severe defoliation. On the Carson National Forest, the maximum one year growth loss averaged 57.1% for the last three outbreaks [2]. The periodic growth loss (average for the same outbreak period) was 22.8% with white fir sustaining greater growth losses than Douglas-fir [2]. Site quality and defoliation intensity are important factors in determining the increment loss severity. A harsh site, combined with persistently severe defoliation, often results in no radial growth for host tree species in a given year.

Overstory top-kill and tree mortality also occur in stands suffering repeated defoliation. The severity of these damages is again linked to site and stocking conditions. In sawtimber-size host trees, top-kill varies from negligible to 60 percent [9,10]. Host tree mortality under these conditions is less severe. In isolated stands, severely defoliated for several consecutive years, tree mortality has occurred to 10 to 19 percent of the overstory. In stands lightly to moderately defoliated, mortality is negligible. Generally, overstocked stands on moderate to poor sites suffer greater levels of top-kill and mortality than well-stocked stands on better sites.

Budworm defoliation may predispose sawtimber-size trees to bark beetle attack. The Douglas-fir beetle, *Dendroctonus pseudotsugae*, and the fir engraver, *Scolytus ventralis*, are two bark beetle species which contribute to the demise of severely defoliated individual trees in mature stands.

Overstory tree mortality in severely infested stands is often associated with dwarf mistletoe and/or root disease. While the interaction of budworm and these pathogens as causal agents of tree mortality is not completely understood, a consensus of pest management specialists agree accumulated stress ultimately kills the tree. Shoestring root disease, *Armillaria mellea*, and annosus root disease, *Fomes annosus*, are common associates with insects in causing tree mortality in Southwestern mixed-conifer forest types [11,12]. Douglas-fir dwarf mistletoe, *Arceuthobium douglasii*, is a serious pest problem in many stands and when associated with bark beetle attacks and defoliation, can result in tree mortality [12].

Recreation and Aesthetic Impacts

The recreation and aesthetic values of National Forest System lands are of considerable importance. The economies of many local communities adjacent to these lands rely heavily on recreation and tourism. Also, aesthetics of surrounding forest lands often contribute significantly to real estate values in these same communities. Stand damage from serious insect epidemics has a negative impact on these values. Scenic quality impact is greatest in areas with little topographic variability, areas with restricted views of distant landscapes, and in sparsely forested areas. In diverse landscapes, the negative impact to scenic quality diminishes, generally being masked by high quality scenic vistas characterized by considerable topographic variability [13]. Defining and measuring the impact of this damage to recreation and aesthetic values is difficult. Models have been developed which predict negative effects on recreation demand resulting from severe insect outbreaks [14]. Methods exist to estimate scenic quality (aesthetics) and the negative impacts of insect damage [13]. While research studies have indicated insect damage adversely effects recreation, aesthetic, and real estate values, actual dollar losses to these values have been difficult to quantify [15].

The perception of WSB damage to scenic quality varies by publics. The principal impact is the perception of scenic quality loss by informed publics. Casual or uninformed observers are affected less by insect damage [13]. Informed publics often associate degradation of scenic quality with potential economic losses in the tourism industry. Thus, these publics may instigate demands that scenic quality be protected from further insect damage.

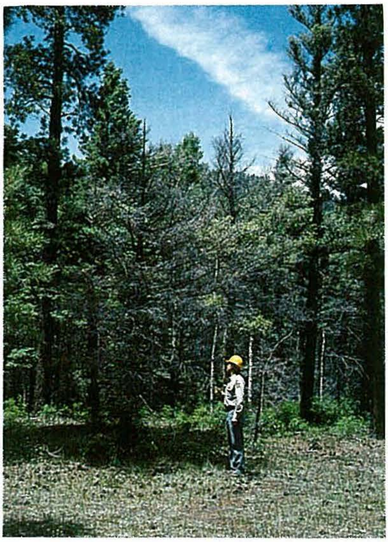

Figure 4. Understory damage caused by WSB.

Figure 5. A ground-based insecticide application to protect foliage.

Management Guidelines

Integrated Forest Protection (IFP), a management decision-making process with a strong emphasis on protecting forest stands from pests, is the recommended approach for managing WSB and other forest pests in the Southwestern Region. IFP is a 9-step process including 3 decision points [1]. This process should be incorporated at all planning levels and is particularly critical at the operational level (i.e. National Forest). IFP requires interaction between various resource functions for successful implementation.

The guidelines described in the next paragraphs follow the principals of IFP and relate to specific steps in the process. These guidelines provide an IFP structure where WSB is a major pest consideration. While WSB is the principal concern of this document, the IFP process must consider, concurrently, all significant forest pests for the stands involved.

Forest Management Objectives

Western spruce budworm, like many forest pests, both affects and is affected by forest management decisions and practices. As described previously, past decisions and practices have generally increased stand and resource damage caused by WSB. Budworm management or, more generally, forest pest management must be considered an integral part of forest management (an IFP approach) if improved protection from severe pest damage is desired.

Integrated Forest Protection is based on well defined forest management objectives upon which the effects of pest populations can be estimated. When specific project plans are being developed, pest consequences or pest management objectives must be concurrently evaluated or developed. As an example, pest management should be considered when planning timber harvest schedules, fire management objectives, silvicultural guidelines, developed recreational goals, visual quality objectives, etc.. In setting planning objectives and formulating actions, the effects of known pest situations on these objectives must be analyzed. Forest plan objectives should be some of the primary determinants when developing an IFP approach to pest management.

Pest Situation Analysis

Pest consequences and pest management objectives are a product of a thorough analysis of the pest situation as it relates to overall planning objectives. This analysis can be a detailed analysis of a specific situation (see Evaluating the WSB Situation) or a brief overview of historic and current pest problems in an analysis area. The analysis depth will depend upon the potential pest damage effects on desired management objectives. For WSB in developed forest areas, pest management objectives could include: (1) reducing stand susceptibility to future damage, (2) protecting stand growth and yield, (3) enhancing budworm larval mortality by reducing host tree density and the occurrence of multi-storied stands, (4) protecting advanced regeneration from top-kill and mortality, (5) improving natural regeneration success, (6) protecting developed recreation sites, and (7) maintaining middle and foreground visual quality. In undeveloped or wilderness areas, different pest management objectives, such as perpetuation of climax forest conditions, are appropriate and desired.

Evaluating the Western Spruce Budworm Situation

The need for specific evaluations generally arises when a budworm outbreak is recognized or when planning proposals are being developed for a budworm susceptible site. The evaluation depth or intensity will depend upon specific management objectives and concerns or known public perceptions of forest damage.

Standardized evaluation techniques exist for WSB. These techniques include: (1) aerial detection surveys to estimate infestation extent and severity, (2) biological evaluation surveys which estimate and predict population trends based on egg mass or larval densities, and (3) stand damage assessment surveys. Forest Pest Management can plan, conduct, analyze, and interpret the results of these surveys. This information is then utilized to formulate possible management alternatives which may serve as the basis for further analyzes.

Alternatives for Western Spruce Budworm Management

Management alternatives fall into three general categories: (1) suppression with insecticides, (2) silvicultural management, and (3) no action. Most alternatives developed for WSB management are variants of, or a combination of these categories. Under an IFP strategy, alternative formulation should utilize the best knowledge available on pest-host interaction and available management techniques to achieve the desired pest management objectives. Thus, alternative formulation requires a data base including information on the pest, host, site, and management goals. Without sufficient specific information, biologically and economically effective alternatives can not be satisfactorily developed.

1. Suppression With Insecticides

Insecticide suppression is a strategy which reduces undesirable stand damages for 2 to 5 years. It is not a long-term WSB management technique, but a short-term strategy since the conditions leading to the outbreak remain unchanged by the treatment. The effectiveness of a suppression strategy is dependent on larval densities at the time of treatment, with longer lasting results linked to lower WSB densities. While suppression is a short-term management strategy, this fact does not solely eliminate it from consideration, but does limit its implementation to situations or stands where WSB caused damages are unacceptable in the short-term.

A variety of chemical and biological insecticides are registered for use against the WSB. Chemical insecticides include carbaryl, acephate, and other broad spectrum insecticides. Biological insecticides are limited to the various formulations of Bacillus thuringiensis (B.t.). Viral insecticides have not proven effective against WSB. The choice of insecticide in a suppression strategy should be the product of a thorough analysis of treatment area specifics including: treatment objectives; aquatic, wildlife, human habitation and other environmental or ecological constraints; biological effectiveness; application technology; and economics.

Insecticide suppression can be achieved through ground applications (treatment equipment located on the ground) or aerial applications. Ground applications are aimed at individual trees with an objective of foliage protection during the current year. The most common application technique utilizes a power hydraulic sprayer (Figure 5).

This equipment is generally effective on accessible trees up to 60 feet in height. Ground applications are generally very successful in protecting foliage. However, they are expensive and thus limited to high value trees usually within residential and developed recreational sites.

Aerial insecticide applications are appropriate where treatment areas are large and objectives are to protect timber and/or scenic/aesthetic values in the short-term. Two aerial insecticide application strategies are generally recognized, population reduction and foliage protection. The population reduction strategy has an objective of reducing insect population densities to low levels, thereby providing the maximum longevity of treatment effectiveness. This strategy usually requires implementation early in an outbreak cycle, before insect populations reach their maximum densities and tree and stand damage becomes severe. The foliage protection strategy involves treatments to save foliage and prevent further serious tree or stand damage. This strategy is usually implemented late in an outbreak cycle and often requires repeat treatments, annually or biannally, until the outbreak subsides.

The longevity of treatment effectiveness is dependent on larval population densities at the time of treatment, a few days of dry weather, and a good application. When population densities are less than about 15 larvae per 100 buds, insecticide applications appear to have longer treatment effectiveness (4 to 5 years) than applications made to larval densities greater than about 20 larvae per 100 buds. Lower budworm population densities are usually encountered in the early stages of an outbreak, possibly the first year or two after defoliation becomes noticeable. Treatments should not be considered necessary when densities are below 5 larvae per 100 buds.

In mountainous terrain, turbine-powered, fixed-wing, agricultural spray aircraft have proven most effective. In rough, steep terrain, turbine-powered helicopters are useful.

There are numerous economic, social, and environmental constraints associated with a decision to undertake insecticide suppression. Thus, this decision must be a product of a well conceived and thorough analysis.

2. Silvicultural Management

This long-term WSB strategy involves manipulating stand age, species composition, density, and height class structure to reduce stand susceptibility/vulnerability to WSB damage. The degree of effectiveness afforded by silvicultural treatments is largely unknown, but experience and logic point to its use as a WSB management tool.

The effectiveness of silvicultural management may extend for decades, but its' implementation to a significant forest area takes decades. Thus, silvicultural management will have little or no visible effect against a current outbreak. It is not a strategy which will protect forest values from an eminent or ongoing budworm outbreak in the short-term.

Silvicultural techniques recommended by the Southwestern Region (FSH 2409.26a Cutting Methods Handbook) to reduce stand susceptibility/vulnerability include:

A. Changing species composition to favor nonhost species.

1. Thinning to remove the more susceptible species (white fir and Douglas-fir).

2. Regeneration cuts heavy enough to favor the establishment of nonhost seral species (pine and aspen).

B. Reducing stand density to improve vigor and reduce stress.

C. Reducing variation in height class to reduce damage to understory trees.

1. Thinning from below

2. Regeneration cuts
   a. Shelterwood seed cuts and final removal cuts (Figure 6.)
   b. Clearcuts

These techniques are normally considered within the planned timber sale program for stands not currently heavily damaged by budworm, and not as remedial measures in heavily damaged stands. Heavily damaged stands involve tree mortality, severe top-kill, non-manageable understory, and significant growth loss. Salvage and presalvage cuts are applicable in heavily damaged stands or in stands in eminent danger of heavy damage. These are remedial measures applied to stands unlikely to survive to planned

rotation or harvest schedule dates. Often salvage and presalvage cuts require deviations from the established timber sale program to capture the expected mortality.

Prescribed fire, although untested as a WSB silvicultural management technique, may be an effective tool to maintain certain stands in a reduced WSB susceptible state. Many white fir, Douglas-fir, and blue spruce habitat types have ponderosa pine as a major seral species. WSB host tree species will eventually succeed pine on these sites as the climax plant association. When stands on these habitat types have a pine overstory, they may be maintained in this successional stage by using prescribed fire to remove WSB host trees in the understory. This technique may be successful on stands well-stocked with ponderosa pine and having a white fir, Douglas-fir, or blue spruce seedling-sapling understory.

Silvicultural techniques should also consider methods favoring WSB predators. For example, tree, shrub, and ground layer vegetation affects habitats for many bird species predatory on budworm. Retention of snags and a diverse array of habitats will contribute to the success of silvicultural strategies [16].

Budworm silvicultural management should not be limited to principal timber producing areas, but should be considered in visual corridor management and in developed recreation areas (i.e. ski areas) where potential budworm impacts are perceived as extremely undesirable. In these areas, judicious silvicultural treatments can enhance and perpetuate the resource as well as reduce spruce budworm susceptibility/vulnerability.

In northern New Mexico, potential western spruce budworm impacts must be a prime consideration in developing silvicultural prescriptions for susceptible mixed conifer stands.

3. No Action

Under this alternative, no action is taken against the WSB. Natural factors will eventually regulate WSB populations and damages associated with the outbreak are acceptible and not conflicting with management objectives. Taking no action is acceptable in many situations. No action situations include stands with low timber, aesthetic, or recreational values where suppression or silviculture are not economically viable or possible; or in stands with low budworm susceptibility, or in stands where social/environmental or managerial constraints preclude any

other actions. The no action scenario also serves as a "point of comparision" for alternative analysis under NEPA (National Environmental Policy Act) requirements. No action should not be an arbitrary decision, but a product of the same analysis used in evaluating suppression or silvicultural action alternatives. Other alternatives are considered when it has been determined the no action alternative is unacceptable.

Decision-Making

In developing an IFP approach to forest management, management goals and objectives in both the short- and long-term, pest situation analyzes, and effective alternative actions must be evaluated and compared within a decision-making process. Within the guidelines previously described, the first decision point occurs when forest management objectives are compared with an analysis of the pest situation. The decision is whether these objectives are threatened by a pest(s) situation. Depending upon the outcome of the first decision, the second decision implements an in-depth pest evaluation, in the case of this document, a WSB evaluation. The third decision selects an appropriate management alternative. Effective alternatives will need to be tailored for the specific situation to maximize biological and economic validity while minimizing adverse effects.

Project Planning and Implementation

Development and implementation of suppression alternatives must comply with NEPA analysis requirements and subsequent project planning and funding requirements. Silvicultural alternatives are normally developed during timber sale planning with appropiate NEPA documentation. Generally, the benefiting staff function (timber, recreation, fire, etc.) provides funding for specific projects.

In planning and implementing specific projects aimed at WSB, particularly suppression activities, the assistance of forest pest management specialists should be sought from the beginning. These specialists have the expertise to plan and conduct these activities and request project funding.

Evaluating Alternative or Project Effectiveness

IFP strategies require consistent monitoring to determine project success or failure. Specific project objectives should be established and their attainment measured. Implemented alternatives may or may not achieve desired effects since WSB populations change over time, either increasing or decreasing in severity, and management goals and objectives may change. These and other possibilities necessitate consistent monitoring, including the monitoring of no action decisions. Alternatives which fail to meet planned objectives need re-evaluation. Successful actions also require monitoring to assure continued success.

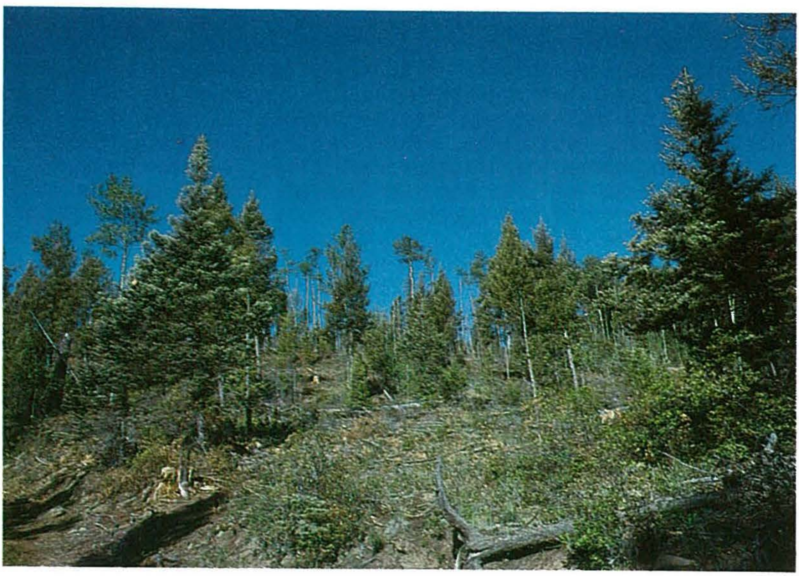

Figure 6. A final overstory removal in a WSB susceptible stand.

Summary

The western spruce budworm is the principal insect defoliator within the mixed-conifer forests in the Southwestern Region. WSB larvae preferably feed on white fir and Douglas-fir foliage in May and June, completing a generation by August. Budworm caused tree and stand damages range from seed and cone destruction to overstory top-kill and limited overstory mortality. Defoliation often negatively impacts the recreation and aesthetic resource. Current WSB outbreaks appear longer and more severe than recorded historic outbreaks. Past fire and timber management action have contributed to the severity of current outbreaks.

The western spruce budworm can adversely influence planned resource objectives and outputs from managed forest lands in the short- and long-term. Integrated Forest Protection is the recommended management approach for WSB and other forest pests. IFP is a 9-step process including 3 decision points. It should be incorporated at all planning levels and requires interaction among various resource functions.

The primary alternatives for WSB management are (1) suppression with insecticides, (2) silvicultural management, and (3) no action. Resulting management actions may involve combinations of these alternatives. Suppression with insecticides consists of aerial or ground treatments with either chemical or biological insecticides and is a short-term strategy. Silvicultural management includes various intermediate and even-age regeneration cutting methods. Prescribed fire is a possible management technique. Silviculture is a long-term management strategy with little effect on current outbreaks.

Setting forest or pest management objectives, evaluating pest situations, determining management alternatives, decision-making, project planning and implementation, and evaluating project effectiveness are all part of the IFP process.

Assistance in western spruce budworm management can be obtained from the following organizations:

Federal and Indian Lands -- USDA Forest Service
Forest Pest Management
517 Gold Ave. SW
Albuquerque, NM 87102
Telephone: (505) 842-3281
FTS 476-3281

State and Private Lands -- Arizona State Land Dept.
Division of Forestry
1624 West Adams
Phoenix, AZ 85007
Telephone: (602) 255-4627

New Mexico Department of Agriculture
P.O. Box 3189
Las Cruces, NM 88003
Telephone: (505) 646-3007

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Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or state extension specialist to be sure the intended use is still registered.